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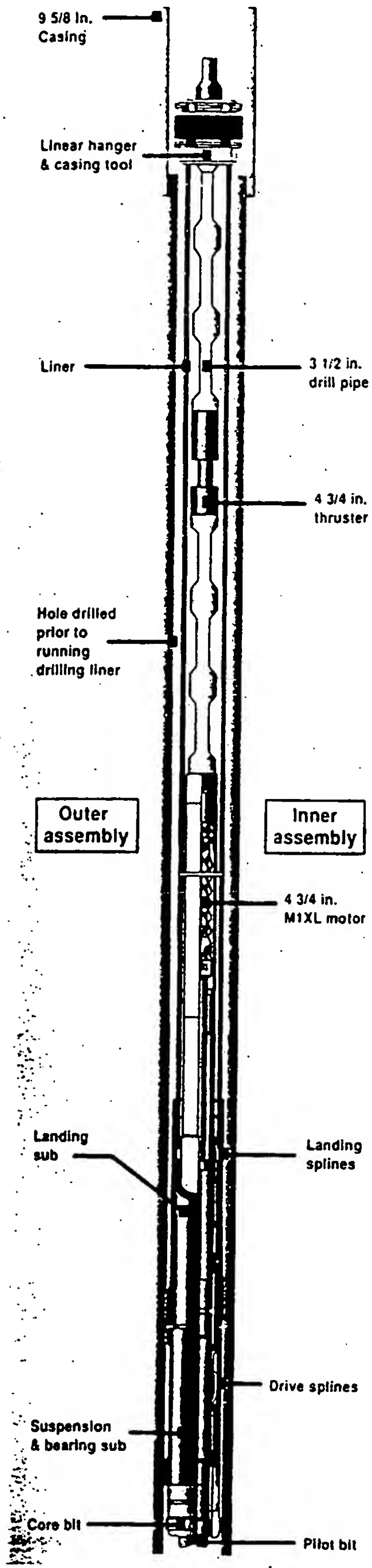
Casing-while-drilling system reduces hole collapse risks

Controlling high differential pressures between adjoining formations.



7 in. Drilling Liner System showing inner and outer assemblies.

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A collapsed hole adds great expense to any drilling project and can, in an extreme case, lead to a well's abandonment. Hole collapse can be caused by a number of drilling conditions including shale swelling, sloughing, and unconsolidated (flowing) sands that cause a hole to "wash out" as soon as it is drilled.

Another cause is an extreme pressure drop between adjoining formations. A new drilling system that sets the liner while drilling has been developed as a means of avoiding severe mud losses and hole collapse.

This system's first applications were in wells in which a formation with high pore pressure was closely followed by a depleted gas reservoir with significantly lower pressures. Typically, drilling into a low-pressure formation with a heavy mud, designed to drill through high-pressure zones, will result in severe mud losses and simultaneous hole collapse.

With this new system, the liner is set concurrently with drilling. Although some mud losses still occur, the liner protects the borehole integrity. When entering the low-pressure formation, heavy mud losses can occur. Drilling continues until the hole collapses. The liner is set when it gets stuck or whenever the target depth is reached.

Once the liner is in place in the "trouble zone", the inner drilling assembly is removed, the liner is cemented, and fluid properties are adjusted to better match the new drilling conditions. At this point normal drilling operations can resume.

System design

Drilling with a liner in place is not a new concept. Until recently, however, the thin liner wall limited the maximum liner loads and restricted rate of penetration (ROP). The new drilling liner makes it possible to drill in this manner with acceptable ROP (even in sliding mode) due to the increase in available downhole motor speed and torque.

The drilling liner system consists of an outer and inner assembly. Both assemblies are temporarily connected via retractable splines which ensure that the inner and outer assemblies are properly aligned with one another. When running in the hole, the splines are retracted and, upon reaching proper alignment, extend automatically. After the liner is set, the process of pulling the inner string from the liner forces the splines to retract once again.

- Inner assembly: The inner assembly consists of a pilot bit, a male sub, a downhole motor and a thruster. The inner assembly's spline male sub houses the retractable drive splines, which transmit torque from the motor to the outer assembly's core bit. This means the core bit and pilot bit turn together at the same rate.

The motor provides torque and rotation while the thruster provides a dynamic length suspension of the inner string with respect to the outer string. This allows the thruster to compensate for the inner and outer assemblies' varying thermal expansions. In addition, the thruster provides the hydraulic weight on bit (WOB).

- Outer assembly: The components that comprise the outer assembly include a core head, female sub, suspension sub (bearing sub) and a landing sub. The outer, lower assembly is connected via a crossover to a standard liner with required length. In addition to delivering the cutting action, the core head provides guidance for the inner assembly's pilot bit. The spline female sub forms a locking mechanism for the inner assembly's retractable male splines. The suspension sub offers longitudinal length suspension and delivers radial guidance.

casing while drilling

continued from page 56

total losses occurred, and the liner stuck. There was no problem setting the hanger or retrieving the inner string. The interval drilled on this well was 42 ft. Subsequent drilling liner runs were scheduled in December 1997 and the Spring of 1998.

North Sea well

The first application of this technology in the North Sea took place in November 1997. In addition, this marked the introduction of a 9 5/8-in. drilling liner system (the Indonesia jobs were all drilled using 7-in. systems).

Although the plan called for drilling the interval in a sliding mode, a rock bit was used

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rather than a PDC bit to reduce torque in the event rotation was necessary. However, the 62-ft interval intersecting the high-pressure cap rock and low pressure reservoir was drilled entirely in the sliding mode.

The liner was set 23 ft into the target formation and the inner string was retrieved without any problems. The liner length used on this job was 6,822 ft. This well also marked the first successful application of a cementing valve.

Conclusions

The successful application of this technology means that there is now a more cost-effective means of controlling the problem of high differential pressures between two adjoining formations. As a result, several more runs are scheduled in both Norway and Indonesia.

With the growing re-entry market and the fact that similar problems exist all over the world, it appears likely that the near future will see this technology expanding into even more operating areas.

To fulfill these requirements, different drilling liner sizes for varying drift diameters will have to be made available. A 7 5/8-in. drilling liner system has been designed for Norway and is scheduled to run in the Spring of 1998.

Despite the successes of the first five runs, there is still some room for improvement. One major aspect will be to suit one inner assembly to different liner drift sizes to reduce logistical requirements and lower inventory.

Another possibility under consideration is a steerable drilling liner that will allow small corrections of the well path. Further refinement of the drilling liner system will require an integrated engineering approach between the drilling and completions disciplines.

Recognizing this, Baker Hughes INTEQ, Baker Oil Tools and Hughes Christensen are working in partnership to improve this technology for tomorrow's drilling requirements.

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